Kw

Cost-Effectiveness Analysis of Ohio Quench Tower Pollution Control Options

Cost-effectiveness (C-E) ratios will be derived for three control options; multiple row baffles, clean water quenching (TDS of 1500 mg/l) and combined multiple row baffles and clean water quenching. The pollution reduction and cost of control for each option are computed for J&L - Campbell, RSC - Warren, RSC - Youngstown, and USSC - Lorain.

The C-E ratio is the total annualized cost of control divided by the annual reduction of pollution. The total annualized cost has two components; annual capital recovery (financial) costs, and annual operation costs.

The costs of clean water quenching for the four Ohio plants were computed from the development document for the effluent limitation guidelines for Iron and Steel. The capital cost of wastewater treatment is based on the size of the facility needed to treat the waste ammonia liquor from by-product cokemaking operations, allowing the quenching water to reach 1500 mg/l TDS. The capital costs for clean water (1500 mg/l) quenching for each plant are:

Define

| | $(000) |
|---|---|
| o Republic - Youngstown | $2408.0 |
| o Republic - Warren | 2145.6 |
| o USSC - Lorain | 3192.3 |
| o J&L - Campbell | 2697.6 |
| Total -- | $10,443.5 |

The total annualized cost is 22.8 percent of the capital cost of clean water quenching. The methodology used to compute this percentage is the present value cash flow method (see table A).

The annual operation costs for clean water quenching include the following costs (from Iron and Steel development document):

- Operation and Maintenance
- Land
- Sludge Disposal
- Hazardous Waste Disposal
- Oil Disposal
- Energy and Power
- Steam
- Waste Acid
- Chemical
- Crystal Disposal

As a percentage of capital cost, the annual operation cost is 17 percent.

TABLE A

Annualized Cost of Clean Water Quenching
(example investment of a $1000.00)

| Useful Life (# of years) | 1] Operation Costs | 2] ITC | 3] Equity Finance | 4] Debt Finance | 5] Depreciation | 6] NCF | 7] MPV |
|---|---|---|---|---|---|---|---|
| 0 | | +100 | -650 | | | -550 | -550 |
| 1 | -85 | | | -70.9 | +69.8 | -86.1 | -83.0 |
| 2 | -85 | | | -65.9 | +95.2 | -55.7 | -51.8 |
| 3 | -85 | | | -61.3 | +84.5 | -61.8 | -55.4 |
| 4 | -85 | | | -57.1 | +78.6 | -63.5 | -54.9 |
| 5 | -85 | | | -53.1 | +73.1 | -65.0 | -54.2 |
| 6 | -85 | | | | | -85.0 | -68.3 |
| . | . | | | | | . | |
| . | . | | | | | . | |
| . | . | | | | | . | |
| . | . | | | | | . | |
| 25 | -85 | | | | | -85 | -34.1 |

NPV of Investment over Useful Life -1835.8

Post-tax annualized cost - $114.1

Pre-tax annualized cost - $228.2 (assumed marginal tax rate of 50.1%)

Pre-tax annualized cost or a percentage of capital cost is 22.8 percent.

Footnotes to Table A:

1. Post-tax operation cost is 8.5% of capital cost (assumed marginal tax rate of 50.1%) and left operation costs in real terms.

(Table A continued)

2. Investment tax credit of 10% from Economic Recovery Act of 1981.

3. Steel Industry will finance capital investments with approximately 65% equity funds and 35% debt; data from FTC's Quarterly Financial Report.

4. Used post-tax weighted cost of capital of 4.46%, see TBS's economic analysis of effluent guidelines for Iron and Steel. Debt payments are put into real terms using a 7.5% inflation factor.

5. Depreciation schedule from Economic Recovery Tax Act of 1981, depreciation in post-tax and put in real terms using a 7.5% inflation factor.

6. Net cash flow which is the sum of the rows in Table A.

7. Net Present Value of the cash flow using a discount rate of 3.72% that includes an inflation rate of 7.5% (calculated from Chemical Engineering plant cost index) and 11.5% rate of return on equity ( calculated from FTC's QFR).

An option to be considered is the treatment of all wastewater used in quenching, bring the TDS concentration in the quench water down to 500 mg/l. The incremental capital cost and annualized cost are the following:

| | Capital Cost $(000) | Annualized Cost $(000) |
|---|---|---|
| Republic-Youngstown | 1523.2 | 347.3 |
| Republic-Warren | 2031.9 | 463.3 |
| USSC-Lorain | 3055.4 | 696.6 |
| J & L-Campbell | 2508.6 | 572.0 |
| Total - | 9119.1 | 2079.2 |

(Table A continued)

Using the functions in Table ____ to calculate the pollution reduced from multiple row baffles and water at 1500 mg/l TDS to water at 500 mg/l will yield the following C-E ratios:

| | $ Per Ton of TSP Reduced |
|---|---|
| Republic - Youngstown | $5890 |
| Republic - Warren | $8740 |
| USSC - Lorain | $8100 - $7300 |
| J & L - Campbell | $8540 - $8060 |
| Aggregate | $7640 |

The annualized costs of clean water quenching (1500 mg/l) for each plant are:

| | $(000) |
|---|---|
| Republic - Youngstown | 549.0 |
| Republic - Warren | 489.2 |
| USSC - Lorain | 727.8 |
| J & L - Campbell | 615.1 |
| Total --- | $2381.1 |

The capital cost of multiple-row baffles for quench towers at the four Ohio Steel plants was estimated by a contractor, and these cost estimates are consistent with the installed capital cost of multiple-row baffles used in the draft NSPS for quench towers and with estimates developed by J & L (memo from W. Wilson of J & L to J. Kunz of Region III, dated 4/21/82). Multiple-row baffle capital costs for each plant are:

(Table A continued)

| | $(000) |
|---|---|
| Republic - Youngstown | 400.0 |
| Republic - Warren | 400.0 |
| USSC - Lorain | 760.0 |
| J & L - Campbell | 820.0* |

The operating costs for baffles are negligible, and these costs were assumed to be zero. Total annualized costs for multiple-row baffles will include annual capital recovery costs and, because baffles have a four year useful life, a periodic replacement cost. To compare properly the costs and pollution reductions from different control options, the time period for each option must be equal. Because an investment in wastewater treatment has a useful life of 25 years, to compare costs/benefits of baffles with clean water quenching, the cost of baffles must also be calculated over a 25 year period. Using the same methodology and financial assumptions will yield a total annualized cost for baffles as a percentage of capital cost of 20.8 percent (see Table B).

TABLE B

Annualized Cost of Multiple-Row Baffles

(example investment of $100.0)

| Time Period | ITC | Finance by Equity | Debt Finance | Depreciation | Replace- 1) ment Cost | NCF | NPV |
|---|---|---|---|---|---|---|---|
| 0 | +10 | -65 | | | | | |
| 1 | | | -11.4 | +11.6 | - | -55.0 | -55.0 |
| 2 | | | -10.6 | +16.4 | - | + 0.2 | + 0.2 |
| 3 | | | - 9.8 | +14.9 | - | + 5.8 | + 5.4 |
| 4 | | | | | - | + 5.1 | + 4.6 |
| 5 | | | | | - | 0 | 0 |
| \| | | | | | -40.0 | -40.0 | -33.3 |
| \| | | | | | \| | \| | \| |
| \| | | | | | \| | \| | \| |
| \| | | | | | \| | \| | \| |
| 25 | | | | | | | 0 |
| | | | | | Total | = | -171.9 |

*J & L's cost estimate to install Carl Still baffles at their Campbell quench towers, but the towers at Campbell have multiple-row baffles; therefore, for the purposes of this study, J & L baffle cost will not be used in the C-E analysis.

| | |
|---|---|
| Post-tax present value annualized cost | - 10.7 |
| Pre-tax present value annualized cost | - 21.4 |
| Annualized cost as a percentage of capital cost | - 21.4% |

Footnote: 1) Useful life of baffles is four years, however, replacement cost is approximately 40 percent of original capital cost and would not be treated as a new capital expenditure in production control, but as a maintenance expenditure.

The annualized costs of multiple-row baffles for each plant are:

| | $(000) |
|---|---|
| Republic - Youngstown | 85.6 |
| Republic - Warren | 85.6 |
| USSC - Lorain | 162.6 |
| J & L - Campbell | --- |

Total --333.8

Taking the emission reductions for each pollution option from Table 8 and dividing the reduction into the appropriate annualized cost will yield the C-E ratio for that control option.

The C-E ratios for requiring clean water (1500 mg/l) quenching and status quo baffles are:

| | $ Per Ton of TSP Reduced |
|---|---|
| Republic - Youngstown | $390 |
| Republic - Warren | $420 |
| USSC - Lorain | $740 |
| J & L - Campbell | $710-$530 |
| Aggregate | $530 |

The C-E ratios for requiring only multiple-row baffles are:

| | $ Per Ton TSP Reduced |
|---|---|
| Republic - Youngstown | $100 |
| Republic - Warren | $120 |
| USSC - Lorain | $510-$140 |
| J & L - Campbell | --- |
| Aggregate | $140 |

The C-E ratios for requiring multiple-row baffles and clean water quenching are (incremental cost of clean water) 1500mg/l:

| | $ Per Ton TSP Reduced |
|---|---|
| Republic - Youngstown | $900 |
| Republic - Warren | $980 |
| USSC - Lorain | $910-$610 |
| J & L - Campbell | $710-$530 |
| Aggregate | $760 |

Attachment B

In order to determine the range of particulate emissions from the three (3) J&L quench towers, Aliquippa No. 3, and Campbell Works Nos. 4 and 5 when operating with 1500 mg/l TDS quench water, the following information and equations were used. In addition, each tower has certain "other" factors that may affect these estimates and are outlined in the text.

| | | | |
|---|---|---|---|
| Aliquippa No. 3 | - | water loss - 110 gal/t coal | |
| | | coal charged | 30.7 tons |
| Campbell No. 4 | - | water loss - 110 gal/t coal | |
| | | coal charged | 17.1 tons |
| Campbell No. 4 | - | same as No. 4 | |

To determine the TDS quench factor equation, I used:

(1) $\frac{mg}{\ell} \times \frac{\ell}{gal} \times \frac{lB}{mg} \times \frac{\text{Quench}}{\text{t coal charged}} \times \frac{\text{gal. water loss}}{\text{quench}} =$ lBTDS/t coal charged

To determine the emission (particulate) factor:

(2) $Y = 0.19\ x + 0.56$ - (APCA Paper Fig. 4-Front Half)

$Y$ = Front Half particulate lb/t coal

$x$ = Quench TDS Factor - lBTDS/t coal

(3) Emissions = .35 lb t coal per 1000 $\frac{mg}{\ell}$ TDS (APCA Fig. 3 Carv Emissions Dat

For Aliquippa No. 3 tower then using equations 1 & 2:

$$1500\ \frac{mg}{\ell} \times \frac{3.785}{1} \times \frac{1}{454{,}000} \times \frac{1}{30.7} \times \frac{(110 \cdot 30.7)}{1} = 1.38 \text{ lBTDS/t coal}$$

$$Y = 0.19\ (1.38) + 0.56$$

$$Y = 0.82 \text{ lB particulate/t coal}$$

Using equation 3

$$Y - \left(\frac{.35}{1000} \quad x \quad 1.5\right)$$

$$Y = .52$$

The baffles in this tower are not very effective due to the spacing left between each slat and the use of only one row. The loss of 110 gallons per ton of coal is believed excessive and the estimated loss is thought to be 90-1-0 gals per t. coal. This tower may be testable.

Campbell No. 4

EQ. 1 $\frac{1500 \times 3.785 \times 1881}{454{,}000\ (17.1)}$ gals $= 1.38$ lBTDS/t.coal

EQ. 2 $Y = .19\ x + 0.56$

$x = 1.38$

$Y = 0.82$ lB particulate/t.coal

EQ. 3 $Y = \frac{.35}{1000} \times 1.5$

$Y = 0.52$

Towers No. 4 and 5 have four rows of baffles and a loss rate of 110 gals/t. coal is not considered possible. Nor should the same emission factor be applied due to use of a more effective baffle arrangement. These towers are not testable.

# UP-STACK WATER FLOW
# AS EXTRAPOLATED FROM
# CYCLONE AND IMPINGER CATCH

| Location | Test Type | | Gallons - Up-Stack | |
|---|---|---|---|---|
| | | | Average | Range |
| Lorain | Clean | | 1649 | 874-2212 |
| | Dirty | | 1895 | 1054-2459 |
| | | Combined Avg. | 1767 | 874-2459 |
| Dofasco | Clean | | 1605 | 587-2964 |
| Gary #3 | Clean | | 2577 | 2230-2804 |
| | Dirty | | 2347 | 2144-2748 |
| | | Combined Avg. | 2462 | 2144-2804 |
| Gary #5 | Clean | | 1240 | 1076-1396 |
| | Dirty | | 1189 | 1115-1265 |
| | | Combined Avg. | 1214 | 1076-1396 |

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Water Loss Rate Gals/t. Coal Charged

| | |
|---|---|
| Lorain | 135 |
| DOFASCO | 100 |
| Gary 3 | 70 |
| Gary 5 | 101 |

Emission Rate when water loss is estimated to be 95 gals/t. coal

Campbell Towers 4 and 5

Eq. 1 $$\frac{1500 \times 3.785 \times (95 \times 17.1)}{454{,}000\ (17.1)} = 1.19$$

Eq. 2 $$y = .19\ (1.19) + .56$$

Emissions = 0.79 lbs. particulate/t. coal charged

Since none of these numbers can be used as definitive answers to the quench tower emission rate question, a range for each of the three towers is presented below. It is solely a questimate of particulate emissions based on past experiences and is thought to be representative of results from an actual sampling program.

Emissions (lbs particulate/t. coal, front half only @ 1500 mg/l TDS)

| | |
|---|---|
| Aliquippa No. 3 | 0.75 - .95 |
| Campbell No. 4 | 0.50 - 0.70 |
| Campbell No. 5 | 0.50 - 0.70 |

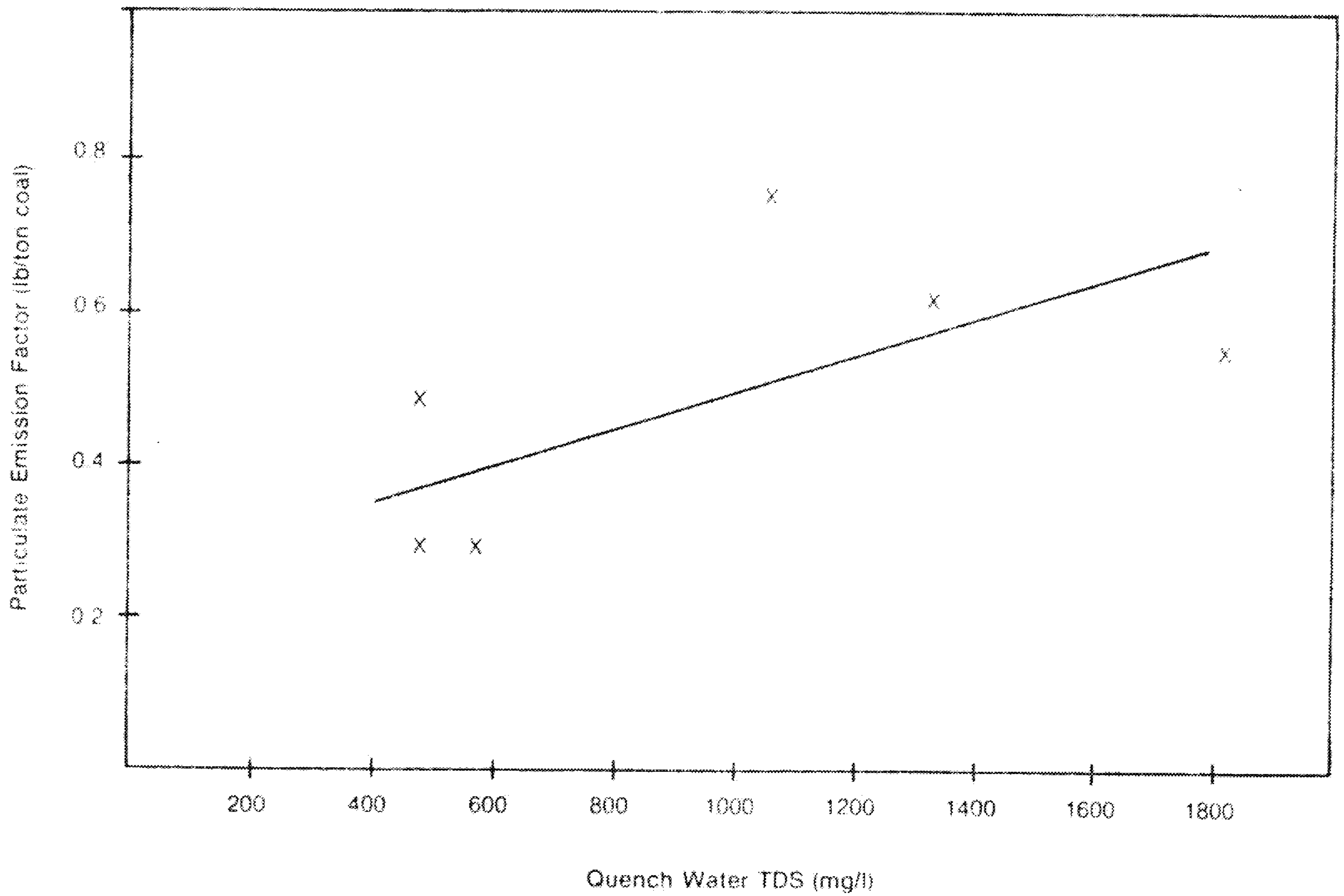


Figure 3. Gary emissions correlation.

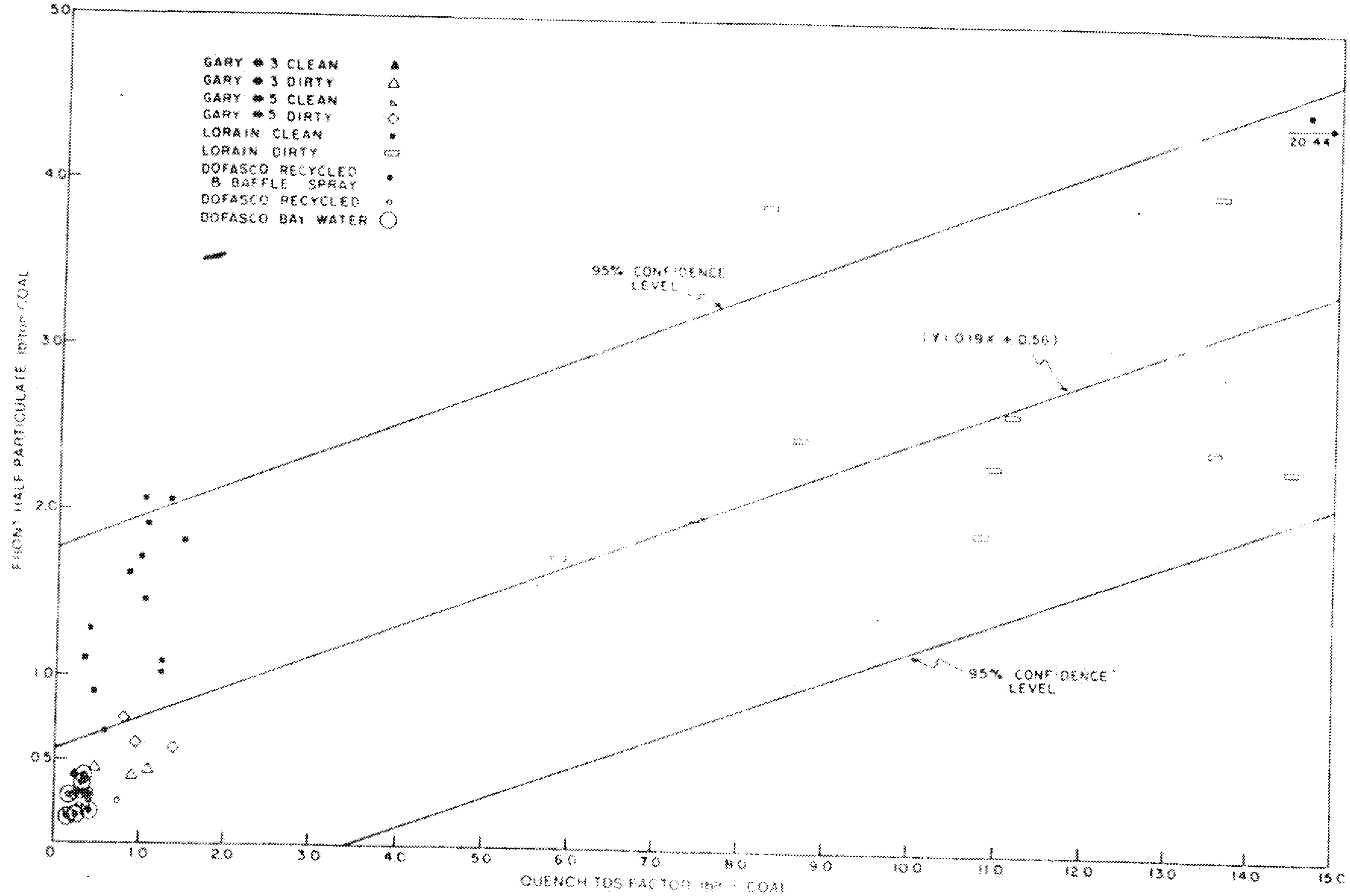


Figure 4. Front half particulate, lb/ton coal.